

Green, D.J. 1980

**An interim report on walleye,
Stizostedion v. vitreum (Mitchill),
stocking and survival data from
five rearing ponds in the vicinity
of Lake Winnipegosis, Manitoba
1978 and 1979.**

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An interim report on walleye, Stizostedion v. vitreum (Mitchill), stocking and survival data from five rearing ponds in the vicinity of Lake Winnipegosis, Manitoba, 1978 and 1979.

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ABSTRACT

This report presents stocking, survival, and release data collected from five walleye rearing ponds located in the Duck Bay area of Lake Winnipegosis.

More extensive study was conducted on two of the ponds, Coleman and Freshwater. These ponds were stocked with a measured number of eyed eggs, whereas, the other ponds were stocked with numbers of fry estimated by eye. Walleye eggs were held one to two days in partially submerged cages until they hatched. Fry were then released to the ponds. Stocking rates varied from 2100 to 5600 fry/ha. The stocking rates for Coleman and Freshwater ponds were reversed from 1978 to 1979. In Freshwater Pond, however, there was a 54% fry mortality during stocking in 1979. An inadequate supply of eggs prevented restocking at the desired rate.

Approximately 6000 to 8000 walleyes were fin clipped in each pond with recaptures varying from 116 to 498. Population estimates based on mark and recapture numbers were calculated. Three different methods were used for comparison. Confidence limits, $P = 0.05$, were determined. For all ponds, except Chartrand Pond, survival rates for the three estimation methods ranged between 2 to 10% difference. There was as much as a 31% difference between survival rates for

Chartrand Pond.

Release of walleyes from rearing ponds was usually started when water temperatures remained at $\leq 14^{\circ}\text{C}$. Handling and spray marking walleye when water temperatures were $> 14^{\circ}\text{C}$ resulted in evident mortality. Total releases for the five rearing ponds were 120,000 and 32,000 in 1978 and 1979, respectively. Due to high mortality rate in Freshwater Pond, presumably caused by interactions with predator fish, only 11 walleye were released in 1979. The monitoring of walleyes in Chartrand Pond was not conducted in 1979 because vandals breached the dike after fry stocking.

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INTRODUCTION

Since 1977, field studies have been conducted on five rearing ponds adjacent to Lake Winnipegosis (Fig. 1) which have been used for rearing young-of-the-year walleye Stizostedion v. vitreum (Mitchill).

Field studies were initiated to evaluate the success of rearing ponds. Fry survival and possibly growth was thought to be better in rearing ponds than in the lake. By releasing walleye fingerlings from rearing ponds the loss to predators as compared to stocking fry directly into Lake Winnipegosis would be reduced.

This report presents number of walleye fry stocked, sampled, spray dyed and released, and population and survival estimates found in the 1978 and 1979 field seasons. Some problems encountered with stocking and releases are discussed.

DESCRIPTION OF THE STUDY AREA

All rearing ponds except Kelly Pond are connected to Lake Winnipegosis by a 24 or 36 inch gated culvert set in a dyke. Coleman and Freshwater ponds were originally back-bays and are closed off from Lake Winnipegosis by rubble dykes. Chartrand and Pacheta were natural ponds and are connected to Lake Winnipegosis by a canal that was dredged from the pond to the lake. Surface areas of the ponds varies from 65 to 109 hectares (Campbell, unpublished data). The ponds are shallow having a maximum depth of 2.5 m.

Because the ponds are shallow, anoxic conditions occur in winter killing any fish remaining. Also, the control gates are closed in winter preventing predator fish such as pike, Esox

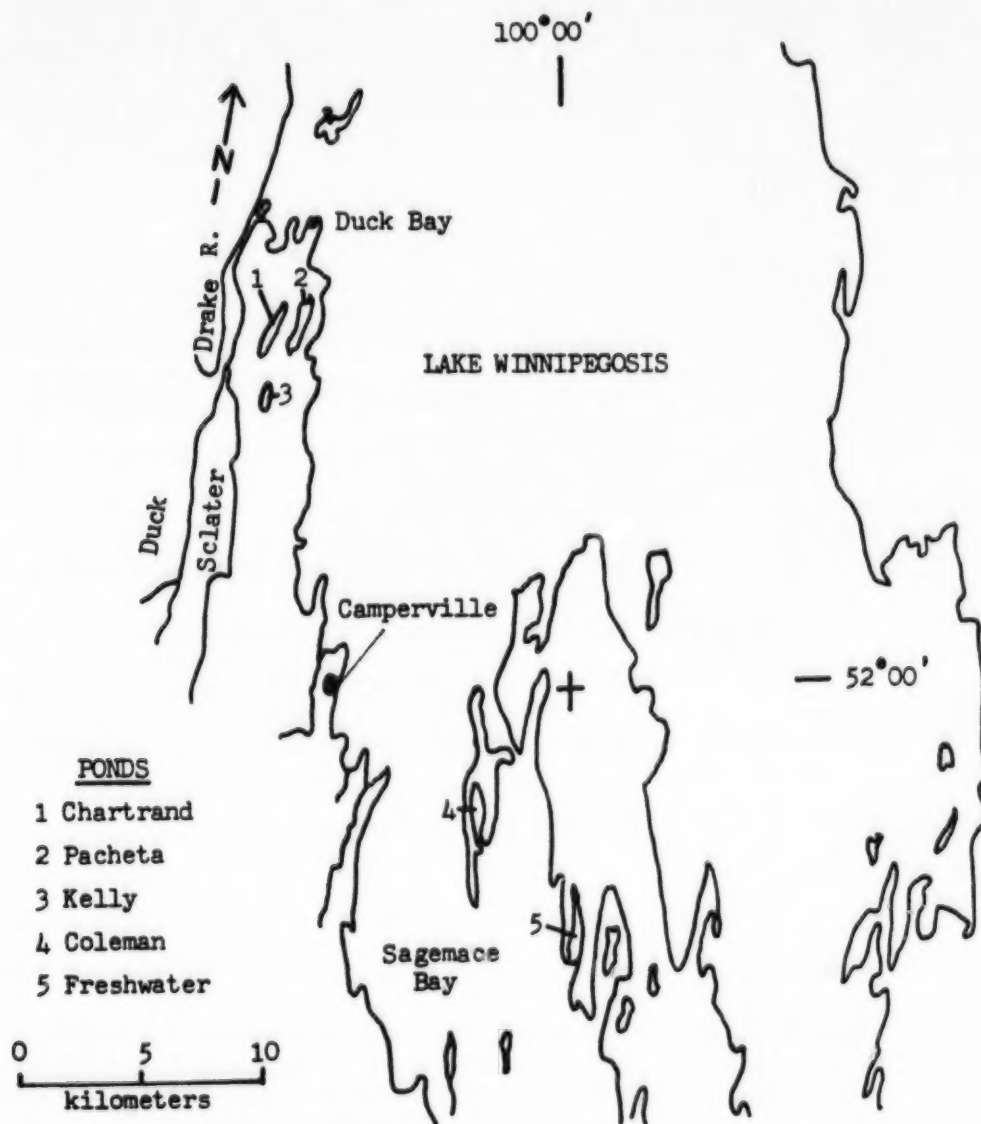


Figure 1. Lake Winnipegosis and the location of five walleye rearing ponds.

lucius (L.), and burbot, Lota lota(L.), from entering the pond during spring breakup. The gates are opened in the fall to release walleye fingerlings. Regular monitoring of walleye was conducted from the time of stocking through to and including releases.

METHODS

Trap nets were set in the mouths of the Duck and Drake rivers by the Duck Bay Hatchery personnel (Fig. 1). Adult walleye moving upstream from Lake Winnipegosis into the Rivers to spawn were caught in the trap nets. Spawn from these walleye was collected, fertilized, and incubated at the Duck Bay Hatchery.

In order to achieve a more accurate assessment of numbers stocked, Coleman and Freshwater ponds were stocked with walleye eggs. Egg numbers were calculated by volumetric measurement which were taken just prior to transporting and stocking them. Number of eggs per ml were 122.9 and 124.9 in 1978 and 1979, respectively (Appendix 1) Huet (1970) found 130 eggs per ml.

One to two days before hatching, eggs were prepared to be stocked. All eggs taken had been fertilized on the same date. The numbers of eggs required per pond were determined and these placed in double polyethylene bags. The bags were filled with approximately 3 l of water and the free air space was filled with pure oxygen. The bags were sealed and transported by truck and boat to the rearing ponds as quickly and carefully as possible. At the rearing ponds, the bags of eggs were placed in the rearing pond water until the water temperatures in the bags and the rearing pond were equal. The eggs were then set in cages which were floated in the rearing ponds.

The egg cages were wooden framed boxes with dimensions of 90 cm x 90 cm x 30 cm. The sides were covered with fine mesh screening (12 meshes/cm) and lined with a very fine meshed cloth which allowed movement of oxygen and water between the cage interior and pond. Walleye eggs were left in the floating cages for 24 hours. All fry had hatched by this time and were in the swim-up stage. Fry were then released along weeds near the shoreline margins of Coleman and Freshwater ponds. Kelly, Chartrand and Pacheta ponds were stocked with unfed fry which had hatched four days previously at the hatchery.

First attempt to catch fry was within 10-14 days after they had been placed in the rearing ponds. A metre net was pulled beside a small boat powered by a 10 hp outboard motor. Twenty-four days after stocking, walleye fry were caught by seine netting within the ponds or by setting in a 1 m trap net made from netting 12 meshes/cm (Beamish, 1972). In 1978 and 1979, samples of 50 and 100 walleye, respectively, were taken at regular intervals. Analysis included length and weight measurements and stomach contents. Length and weight measurements were taken and stomach contents were examined (Gillies and Green, 1980). When the walleye reached an average of 75-80 mm in fork length, mark and re-capture procedures (Ricker, 1975) were conducted on the ponds. The left pectoral fin was clipped off and fry were released back into the pond.

During September, when the surface water temperature dropped to about 14°C, frame trap nets were placed so as to completely enclose the rearing pond exit to Lake Winnipegosis and the control gate was opened. Any walleye leaving the rearing pond, therefore, were caught in the frame net. Kelly Pond required manual transfer of walleye from the rearing pond to Lake Winnipegosis. Fry were caught in frame trap nets,

transported and then released into the lake.

Except for Kelly Pond, all walleye released were individually counted and checked for clips and non-clips. Release numbers from Kelly Pond were estimated by weight. Each day a sample of 100 walleye were weighed. The total weight of walleye released was then divided by the average weight of the sample. This gave an approximate number of fish released.

A fluorescent dye was sprayed onto walleye using compressed air under 110 psi. Walleye were then released into Lake Winnipegosis. Different dye colours were used for each year.

Population estimates based on fin-clipped and recaptured walleye numbers were calculated.

RESULTS

Pond stocking

Numbers of fry released into rearing ponds in 1978 and 1979 are shown in Table 1.

Egg mortality found in egg cages was less than 1%. Almost all mortality occurred with fry, therefore volumetric measurements were conducted for fry (Appendix 2). Table 2 gives mortality of fry for 1978 and 1979.

1978: Eggs were placed within egg cages on May 17 and fry released into Freshwater and Coleman ponds on May 20. Because of a 57% mortality rate in Coleman Pond, a second batch of eggs (349,000) was placed in cages on May 23 and fry released on May 24. Negligible mortality was noticed from the second batch of eggs.

1979: Number of eggs stocked in Coleman and Freshwater ponds was reversed. Eggs were placed in egg cages on May 31 and fry released

Table 1. Walleye rearing pond stocking rates, 1978 and 1979.

Location	Number stocked		Area (ha)	Stocking rate (no./ha)	
	1978	1979		1978	1979
Coleman	649,000	252,000	117	5,547	2,154
Freshwater	244,000	286,000	105	2,324	2,724
Kelly*	200,000	200,000	65	3,077	3,077
Chartrand*	275,000	275,000	109	2,523	2,523
Pacheta*	575,000	575,000	105	5,476	5,476
Total	1,940,000	1,590,000	501	3,872	3,174

*Numbers of fry stocked were estimated by eye.

Table 2. Mortality of caged walleye fry in Coleman and Freshwater ponds before stocking, 1978 and 1979.

Location	1978	1979
Coleman	398,000 ¹	-
Freshwater	35,000	334,000

¹This mortality was replenished with a second batch of eggs (349,000) which brought the total number released into the pond to 649,000.

into the ponds on June 1. Negligible mortality occurred in Coleman Pond, but Freshwater Pond had 54% of the fry die. No attempt was made to restock Freshwater Pond to the original stocking number as a sufficient number of walleye eggs was not available.

Sample collections and fin clipping

1978: Walleye were collected from all rearing ponds at one week intervals. These fish were weighed, lengths measured, and stomach contents examined.

When the walleye attained an average of 80-90 mm in fork length (first week of August), the left pectoral fin was clipped off. Table 3 shows numbers of walleye that were fin clipped and taken in sample collections.

1979: Walleye were collected from Coleman and Freshwater ponds at two week intervals, but were collected from Kelly and Pacheta ponds at intervals of four weeks. At Chartrand, vandals breached the control dike within a week after fry had been stocked. Therefore, it was not sampled in 1979.

When the walleye reached an average of 80 mm in fork length (second week of August), fry were fin clipped in Coleman and Freshwater ponds. No fin clipping was done in any of the other rearing ponds. Table 4 shows numbers of walleye that were fin clipped and taken for sample collections in Coleman and Freshwater ponds.

Fin clipping of walleye in Freshwater Pond was attempted, but because of pike within the pond, no results could be obtained. Yearling pike had entered the pond through the control gate which had not been properly closed off during the winter.

Table 3. Summary of sampled, clipped and recaptured walleye fry for the five rearing ponds, 1978.

Location	Number of fish sampled	Number of fish clipped & released	Number of recaptures (released back to pond)
Coleman	1,452	7,678	150
Freshwater	996	8,155	498 ¹
Kelly	1,099	5,408	157 ²
Chartrand	1,071	5,705	127
Pacheta	1,012	5,719	128

¹ 4 clips due to mortality included in sample collection.

² 2 clips due to mortality included in sample collection.

Table 4. Summary of sampled, clipped and recaptured walleye fry for the five rearing ponds, 1979.

Location	Number of fish sampled	Number of fish clipped & released	Number of recaptures (released back to pond)
Coleman	1,008	6,159	116
Freshwater	536	81	1
Kelly	508	-	-
Chartrand	-	-	-
Pacheta	501	-	-

Releases and spray marking

In 1978 and 1979, releases from Coleman, Freshwater, Kelly, and Pacheta rearing ponds were started after September 18 when surface water temperatures remained at $\leq 14^{\circ}\text{C}$. In 1978, walleye releases from Chartrand Pond started on September 3. However, surface water temperatures often fluctuated above 14°C . Spray marking walleye when water temperatures were $> 14^{\circ}\text{C}$ resulted in evident mortality.

An attempt was made to spray mark all fish released. However, on days of few fish or due to mechanical problems some fish were not sprayed. Total numbers of fish (including number sampled, net mortality and net predation) and number of fish spray marked and released for 1978 and 1979 are shown in Tables 5 and 6, respectively.

Population estimates

Three different methods were used for computing population estimates.

Method 1 (Schnabel) and Method 2 (Schumacher and Eschmeyer): Both methods, from Ricker (1975), were calculated from counts of fin clippings and recapturing fin clipped walleye prior to fingerlings being released from rearing ponds (Appendix 3).

The modified Schnabel (Chapman 1952, 1954)

$$N = \frac{\sum (C_t M_t)}{\sum R_t + 1}$$

and the Schumacher and Eschmeyer

$$\frac{1}{N} = \frac{\sum (M_t R_t)}{\sum (C_t M_t^2)}$$

Table 5. Number of walleyes released, spray dyed, and total number (including number sampled, net predation and net mortality) taken from rearing ponds, 1978.

Location	Total number of live releases	Number sprayed	Total number taken from rearing pond
Coleman	65,121	20,826	70,061
Freshwater	23,110	14,665	29,023
Kelly	18,182 ¹	18,182	19,325
Chartrand	11,860	11,696	12,957
Pacheta	788	763	992
Total	119,061	66,132	132,358

¹Estimated number by weight

Table 6. Number of walleyes released, spray dyed, and total number (including number sampled, net predation and net mortality) taken from rearing ponds, 1979.

Location	Total number of live released	Number sprayed	Total number taken from rearing ponds
Coleman	12,057	11,765	13,118
Freshwater	11	-	841
Kelly	19,300 ¹	16,817	19,808
Chartrand	-	-	-
Pacheta	794	661	1,295
Total	32,162	29,243	35,062

¹Estimated number by weight

were used where:

N = population estimate

C_t = total catch

M_t = number of fin clipped (marked) fish at large

R_t = number of recaptures

Confidence limits ($P = .05$) were calculated according to Ricker (1975).

Method 3 (J. S. Campbell, pers. comm.): This method was calculated using counts of fin clipped and unmarked walleye in the pond after release had begun (Appendix 4). During release, an individual population estimate was calculated for each catch period using the modified Petersen formula:

$$\bar{N} = \frac{(M + 1) (C + 1)}{R + 1}$$

where:

$\bar{N}$ = number in population

M = number fin clipped (marked)

C = total number caught

R = number of recaptures

Each successive estimate ($\bar{N}$) was corrected by subtracting the previous number of fish released. The weighted estimate (N_w) was found using

$$N_w = \frac{\sum \bar{N} C}{\sum C}$$

where:

N_w = weighted population estimate

$\bar{N}$ = $\bar{N}$ minus the total of previous number of fish caught and released

C = total catch

Confidence limits ($P = .05$) were found by calculation of standard error, then multiplying standard error by the t-value equal to $(m - 1)$ degrees of freedom where m = number of catches observed. Standard error = $\frac{s}{\sqrt{m}}$ where s = variance. The formula for variance is

$$s = \sqrt{\frac{\sum C (\bar{N} - N_w)^2}{\sum C (m - 1)}}$$

In 1978 fin clipping was done in all five rearing ponds, while in 1979 fin clipping was done in Coleman and Freshwater ponds only. Population estimates were calculated for all five ponds in 1978 (Table 7), but only for Coleman Pond in 1979 (Table 8). Because of pike in Freshwater Pond, walleye weren't caught in numbers to make an acceptable estimate.

Survival rates for the rearing pond varied from 10-51% (Table 9). The rates were determined from relationship between number of fry stocked to the population estimate that was calculated.

DISCUSSION

In 1978, mortality of hatched fry within egg cages was thought to be due to suffocation caused from overcrowding. Two floating egg cages (350,000 and 150,000 eggs per cage in Coleman and Freshwater, respectively) were used per pond. The least mortality occurred in Freshwater Pond. Therefore, the second batch of eggs placed in Coleman Pond had a maximum of 100,000 eggs per cage. Negligible mortality was observed. Six cages with a maximum of 125,000 eggs per cage were used in 1979. However, considerable mortality still occurred.

Table 7. Population estimates for walleye rearing ponds, 1978.

Location	Population estimate & range	Method 1	Method 2	Method 3
Coleman	min	151,188	131,990	163,550
	estimate	176,224	174,180	167,917
	max	208,150	256,030	172,284
Freshwater	min	55,106	53,341	34,528
	estimate	60,043	60,420	36,190
	max	65,684	69,665	37,852
Kelly	min	76,388	72,998	89,743
	estimate	88,745	88,154	101,859
	max	104,421	111,252	113,975
Chartrand	min	99,678	104,758	49,033
	estimate	119,613	135,545	50,753
	max	146,312	191,958	52,473
Pacheta	min	94,504	84,253	50,004
	estimate	111,485	107,359	60,041
	max	133,583	147,930	70,078

Table 8. Population estimates for Coleman rearing pond, 1979.

Location	Population estimate & range	Method 1	Method 2	Method 3
Coleman	min	110,153	90,444	117,998
	estimate	130,979	120,450	122,752
	max	158,442	180,240	127,506

Table 9. Percent survival rates for rearing ponds, 1978 and 1979.

Location	1978			1979		
	Method 1	Method 2	Method 3	Method 1	Method 2	Method 3
Coleman	27	27	26	51	47	49
Freshwater	25	25	15	N.D.	N.D.	N.D.
Kelly	44	44	51	N.D.	N.D.	N.D.
Chartrand	43	49	18	N.D.	N.D.	N.D.
Pacheta	19	19	10	N.D.	N.D.	N.D.

N.D. = no data

Mortality in 1979, and possibly 1978, could have been due to improper techniques used when measuring the quantities of eggs. Eggs for Coleman Pond were siphoned off incubation jars with a steady stream of water and negligible mortality of hatched fry occurred in the egg cages. Eggs taken from Freshwater Pond had most of the water drained off when the quantity needed for stocking was measured. Over half of the fry from these eggs died within 24 hours of hatching. The water may have acted as a cushioning agent preventing damage to the unhatched fry. The best method for measuring a quantity of eggs, therefore, seemed to be siphoning the eggs off the incubation jars directly into the measuring vessel.

Volumetric measurements conducted for fry mortality from Freshwater Pond showed more than double the number of fry/ml in 1979 than in 1978. The numbers for 1979 are probably an overestimation caused from the method of measuring in a graduated 50 ml centrifugal test tube. Fry were dropped in the test tube and allowed to settle. More fry were added until a 20 ml volume was obtained. Most of the fry also had broken yolk sacs which allowed more fry to be contained within a given volume. Volume measurements by water displacement would have been better. If the 1979 fry mortality was overestimated, then survival estimates based on population estimates and number stocked would also be overestimated. However, virtually all walleye were out-competed by a predator species in Freshwater Pond. Therefore, population and survival estimates were not calculated in 1979.

Releases of fry from rearing ponds was usually in the third week of September when water temperatures were $\leq 14^{\circ}\text{C}$. In 1978, releases from Chartrand Pond began on September 2 when the surface water temperature fluctuated from $14-19^{\circ}\text{C}$. Handling and spray dyeing walleye at this temperature range caused the fish to become

sluggish and in many instances die. Some of these walleye were noticed near the release net after they had been released. These walleye usually had paralysis and extensive fungal growth on the caudal peduncle. With water temperatures $< 15^{\circ}\text{C}$ spray dyeing walleye was achieved with negligible mortality. Therefore, releases for the other ponds were begun when water temperatures tended to remain at $\leq 14^{\circ}\text{C}$.

There was no indication that spray dyeing directly affected the walleye. In 1977 a sample of spray dyed walleye and an equal number of non-spray dyed walleye were taken into the Freshwater Institute in Winnipeg. Survival of the two groups was monitored over winter. Walleye from both groups perished but, with no significant difference (J. S. Campbell, pers. comm.).

Walleye also showed signs of stress when exposed to light. When released into the lake, walleye immediately moved towards the bottom. Prolonged exposure to light caused the colouration in walleye to lighten. Using dark coloured holding tubs and creating shade seemed to reduce the colouration change.

In 1978, population estimates were calculated for all five rearing ponds. In 1979, fin clipping and calculation of population estimates were performed for Coleman Pond only. No estimate was obtained for Freshwater Pond because walleye numbers had been depleted through the summer. Trap netting within Freshwater Pond also caught pike and examination of their stomachs revealed walleye. Most of the walleye were probably caught by pike because of confined space in the net. A gill net gang $1\frac{1}{2}$ ", 2" and 3" meshes was initially set in Freshwater Pond on June 17. Each set was checked on a daily basis. From 51 lifts 2,103 pike were caught, but only 9 walleye were found within these

pike stomachs.

Interspecific competition for food and space as well as predation may have affected walleye survival in Freshwater Pond. Most pike stomachs contained similar food organisms that were found in walleye stomachs after mid-July (Gillies and Green, 1980).

SUMMARY

1. Total walleye fry stocked in five rearing ponds was 1,940,000 and 1,590,000 in 1978 and 1979, respectively.
2. Egg mortality found in egg cages was < 1%.
3. Fry mortality in egg cages was as much as 57% and 54% in 1978 and 1979, respectively.
4. Approximately 6,000-8,000 walleye were fin clipped in each pond in 1978 and in Coleman Pond in 1979.
5. A total of 119,061 and 32,162 walleye fingerlings were released from rearing ponds in 1978 and 1979, respectively.
6. A total of 66,132 and 29,243 walleye were spray dyed during release in 1978 and 1979, respectively.
7. Releases usually began when water temperatures remained at $\leq 14^{\circ}\text{C}$. Spray marking walleyes when water temperatures were $> 14^{\circ}\text{C}$ resulted in evident mortality.
8. Population estimates were calculated using three methods. Confidence limits were found for $P = 0.05$.
9. For all ponds, except Chartrand Pond, survival rates for the three methods ranged between 2 to 10% difference. There was as much as a 31% difference between survival rates for Chartrand Pond.
10. Walleye showed signs of stress when exposed to light, however, using dark coloured holding tubs and creating shade seemed to reduce the stress.

11. Because of pike in Freshwater Pond only 11 walleye were released in 1979.

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Appendix 1. Volumetric measurements of eyed walleye eggs used to determine stocking of eggs in 1978 and 1979.

1978			1979		
Volume (ml)	Egg no.	Egg no./ml	Volume (ml)	Egg no.	Egg no./ml
1000	122890.45	122.9 ¹	25	3065	122.60
			25	3055	122.20
			25	3018	120.72
			25	3299	131.96
			25	3100	124.00
			125	15537	124.292

¹ converted from imperial to metric measurement, 1 quart = 139,666 eggs.

Appendix 2. Volumetric measurements of fry mortality that occurred in egg cages during stocking, 1978 and 1979.

1978				1979			
Coleman				Freshwater			
Volume	Fry no.	Fry/ml		Volume	Fry no.	Fry/ml	
18.5	1194	64.54	9.0	594	2927	146.35	
15.5	966	62.32	11.5	799	2774	138.70	
15.0	974	64.93	8.0	752	2728	136.40	
16.0	1007	62.94	7.0	739	2940	147.00	
19.0	1275	67.11	9.0	686	2947	147.35	
21.0	1410	67.14	9.5	651	2782	139.10	
17.0	1196	70.35	13.0	804	2778	138.90	
16.5	1015	61.52	4.5	331	2878	143.90	
25.0	1659	66.36	7.0	676	2702	135.10	
16.0	1091	68.19	6.0	455	2867	143.35	
179.50	11787	65.54	84.50	6487	28323	141.62	

Appendix 3(a). Method 1 (Schnabel), and method 2 (Schumacher and Eschmeyer) population estimates for Coleman Pond, 1978.

Date	C _t	R _t	No. marked	M _t	M _t R _t	C _t M _t	C _t M _t ²	R _t ² /C _t
Aug. 7	744	0	694	0	0	0	0	0
14	30	1	0	694	694	20,820	14,449,080	0.0333
15	517	3	444	694	2,082	358,798	249,005,812	0.0174
21	64	0	11	1,138	0	72,832	82,882,816	0
23	746	3	742	1,149	3,447	857,154	984,869,946	0.0121
26	2,271	29	2,241	1,891	54,839	4,294,461	8,120,825,751	0.3703
27	1,734	22	1,711	4,132	90,904	7,164,888	29,605,317,216	0.2791
28	174	1	127	5,843	5,843	1,016,682	5,940,472,926	0.00375
Sept. 3	699	43	606	5,970	256,710	4,173,030	24,912,989,100	2.6452
10	345	17	278	6,576	111,792	2,268,720	14,919,102,720	0.8377
11	543	17	476	6,854	116,518	3,721,722	25,508,682,588	0.5322
12	363	14	0	7,330	102,620	2,660,790	19,503,590,700	0.5399
	8,230	150			745,449	26,609,897	129,842,188,655	5.2730
95% confidence range								
Schnabel estimate; $\hat{N} = 176,224$				151,188-208,150				
Schumacher and Eschmeyer estimate; $\hat{N} = 174,180$				131,990-256,030				

Appendix 3(b). Method 1 (Schnabel), and method 2 (Schumacher and Eschmeyer) population estimates for Freshwater Pond, 1978.

Date	C _t	R _t	No.-marked	M _t	H R _{t t}	C M _{t t}	C M ² _{t t}	R ^{2/C} _{t t}
Aug. 6	1,144	0	1,094	0	0	0	0	0
14	82	0	32	1,094	0	89,708	98,140,552	0
20	61	1 ¹	11	1,126	1,126	68,686	77,340,436	0.0164
21	40	0	40	1,136	0	45,440	51,619,840	0
26	274	2	269	1,176	2,352	322,224	378,935,424	0.0146
27	350	3	297	1,445	4,335	505,750	730,808,750	0.0257
28	206	10	196	1,742	17,420	358,852	625,120,184	0.4854
29	325	11	312	1,938	21,318	629,850	1,220,649,300	0.3723
30	291	5	286	2,250	11,250	654,750	1,473,187,500	0.0859
31	187	3	184	2,536	7,608	474,232	1,202,652,352	0.0481
Sept. 2	2,889	154 ²	2,687	2,720	418,880	7,858,080	21,373,977,600	8.2091
11	137	7 ³	79	5,405	37,835	740,485	4,002,321,425	0.3577
16	3,008	290	2,668	5,483	1,590,650	16,498,880	90,496,356,800	27.9588
21	178	12	0	8,151	97,848	1,451,412	11,834,813,448	0.8090
	9,172	498			2,210,622	29,961,322	133,565,923,611	38.3830
Schnabel estimate; N̂ = 60,043								
Schumacher and Eschmeyer estimate; N̂ = 60,420								

95% confidence range
55,106-65,684

53,341-69,665

Schnabel estimate; $\hat{N} = 60,043$

Schumacher and Eschmayer estimate: $\hat{N} = 60,420$

**95% confidence range
55,106-65,684**

55, 106-65, 684

53,341-69,665

1 1 clipped walleye collected

2 2 clipped walleye collected

1 clipped walleye collected

Appendix 3(c). Method 1 (Schnabel), and method 2 (Schumacher and Eschmeyer) population estimates for Kelly Pond, 1978.

Date	C_t	R_t	No. marked	M_t	$M_t R_t$	$C_t M_t$	$C_t M_t^2$	R_t^2 / C_t
Aug. 3	65	0	14	0	0	0	0	0
8	1,843	1	1,792	14	14	25,802	361,228	0.0005
16	760	7	701	1,806	12,642	1,372,560	2,478,843,360	0.0645
22	829	24 ¹	755	2,507	60,168	2,078,303	5,210,305,621	0.6948
29	128	9	119	3,260	29,340	417,280	1,360,332,800	0.6328
31	405	19	368	3,379	64,201	1,368,495	4,624,144,605	0.8914
Sept. 1	497	18	478	3,747	67,446	1,862,259	6,977,884,473	0.6519
3	417	28	336	4,225	118,300	1,761,825	7,443,710,625	1.8801
4	366	13	351	4,561	59,293	1,669,326	7,613,795,886	0.4617
5	233	9	173	4,912	44,208	1,144,496	5,621,764,352	0.3476
12	312	22	240	5,085	111,870	1,586,520	8,067,454,200	1.5513
19	138	7	81	5,325	37,275	734,850	3,913,076,250	0.3551
	5,993	157			604,757	14,021,716	53,311,673,400	7.5317

Schnabel estimate; $\hat{N} = 88,745$ 95% confidence range
76,388-104,421

Schumacher and Eschmeyer estimate; $\hat{N} = 88,154$ 72,998-111,252

¹ 2 clipped walleye collected

Appendix 3(d). Method 1 (Schnabel), and method 2 (Schumacher and Eschmayer) population estimates for Chartrand Pond, 1978.

Date	C _t	R _t	No. marked	M _t	M _t R _t	C _t M _t	C _t M _t ²	R _t ² /C _t
Aug. 5	55	0	15	0	0	0	0	0
9	238	0	188	15	0	3,570	53,550	0
11	58	0	58	203	0	11,774	2,390,122	0
12	316	1	314	261	261	82,476	21,526,236	0.0032
18	57	1	30	575	575	32,775	18,845,625	0.0175
19	44	0	31	605	0	26,620	16,105,100	0
20	129	0	128	636	0	82,044	52,179,984	0
21	52	0	51	764	0	39,728	30,352,192	0
23	480	5	425	815	4,075	391,200	318,828,000	0.0521
24	468	9	459	1,240	11,160	580,320	719,596,800	0.1731
25	358	10	347	1,699	16,990	608,242	1,033,403,158	0.2793
26	162	3	159	2,046	6,138	331,452	678,150,792	0.0556
27	115	3	112	2,205	6,615	253,575	559,132,875	0.0783
28	160	2	158	2,317	4,634	370,720	858,958,240	0.0250
29	1,042	31	1,007	2,475	76,725	2,578,950	6,382,901,250	0.9223
30	2,058	39 ¹	1,963	3,482	135,798	7,165,956	24,951,858,792	0.7391
	5,792	104			262,971	12,559,402	35,644,282,716	2.3455
95% confidence range								
99,678-146,312								
Schnabel estimate; $\hat{N} = 119,613$								
Schumacher and Eschmayer estimate; $\hat{N} = 135,545$								
104,758-191,958								

¹ 5 clipped walleye collected

Appendix 4(e). Method 3 population estimate for Pacheta Pond, 1978.

Date	C	R	M	$\bar{N}$	$\bar{C}$	$\bar{N}$	$\bar{C}$	$\bar{N}$	$\bar{C}$	$(\bar{N}-N_u)^2 C$
Sept. 26	392	31	5,719	70,249	70,249	27,537,608	4,08477	$\cdot 10^{10}$		
27	87	8	5,688	55,626	55,234	4,805,358	2,01033	$\cdot 10^{09}$		
28	236	28	5,680	46,427	45,948	10,843,728	4,68726	$\cdot 10^{10}$		
29	48	4	5,652	55,399	54,684	2,624,832	1,37748	$\cdot 10^{09}$		
	763					45,811,526	9,11081	$\cdot 10^{10}$		

Weighted N: $\hat{N}_u = 60,041$
 $n = 6,308.9$

95% confidence range
50,004-70,078

Standard error = 3,154.5

Appendix 4(f). Method 3 population estimate for Coleman Pond, 1979.

Date	C	R	N	$\bar{N}$	$c \bar{N}$	$c \bar{N}C$	$(\bar{N} - N_u)^2 C$
Sept. 19-21	2,114	93	6,159	138,600	138,600	293,000,400	5,30950 · 10 ¹¹
22-24	1,412	67	6,066	126,069	123,955	175,024,460	2,04346 · 10 ⁰⁹
25-27	3,715	158	5,999	140,226	136,700	507,840,500	7,22741 · 10 ¹¹
28-30	2,157	100	5,841	124,822	117,581	253,622,217	5,76765 · 10 ¹⁰
Oct. 01-04	950	40	5,741	133,186	123,788	117,598,600	1,01963 · 10 ⁰⁹
06-08	420	21	5,701	109,116	98,768	41,482,560	2,41598 · 10 ¹¹
10-12	62	3	5,680	89,476	78,708	4,879,896	1,20272 · 10 ¹¹
13-15	386	27	5,677	78,478	67,648	26,112,128	1,17207 · 10 ¹²
16-18	559	40	5,650	77,184	65,968	36,876,112	1,80245 · 10 ¹²
19-22	525	25	5,610	113,515	101,740	53,413,500	2,31790 · 10 ¹¹
	12,300					1,509,850,373	4,88261 · 10 ¹²

95% confidence range
117,998-127,506

Weighted N: $\hat{N}_u = 122,752$

$s = 6,641.3$

Standard error = 2,101.7